[Ideas For Design]

Voltage-To-Current Converter Works From A Single-Supply Rail

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Voltage-to-current converters feeding to grounded loads often find their way into industrial measurements and control applications. The conventional textbook circuit needs both positive and negative-supply rails (*Fig. 1*). In this circuit:

$$e_{in} - e_1 = I_L R_S$$

Therefore, the load current is:

$$I_L = e_{in}/R_S - e_1/R_S$$

The first term is proportional to the input voltage e_{in}, and the second term is a constant. Here, e_1 is derived from the negative power-supply rail through a potentiometer:

$$I_L = e_{in}/R_S + (-e_1)/R_S$$

R_S is selected so that the first term gives 16 mA for full-scale input voltage, and the potentiometer is adjusted so that the second term provides a constant 4 mA. In effect, the output ranges from 4 to 20 mA, corresponding with zero to full input voltage. But failure of the negative power supply causes erroneous output. Moreover, there may be equipment where the negative power supply is not available, requiring generation just for thi

In such cases, there's a slightly different circuit that works on a single-supply rail (*Fig. 2*). This circuit uses one half of the quad operatio LM324. The first amplifier is configured as a subtractor, while the second amplifier is configured as a current converter.

The output of the first amplifier at A equals e_1 minus e_{in}. Here, e_1 is derived from the positive power supply by potentiometer P_1. The vo equals V minus $I_L R_S$.

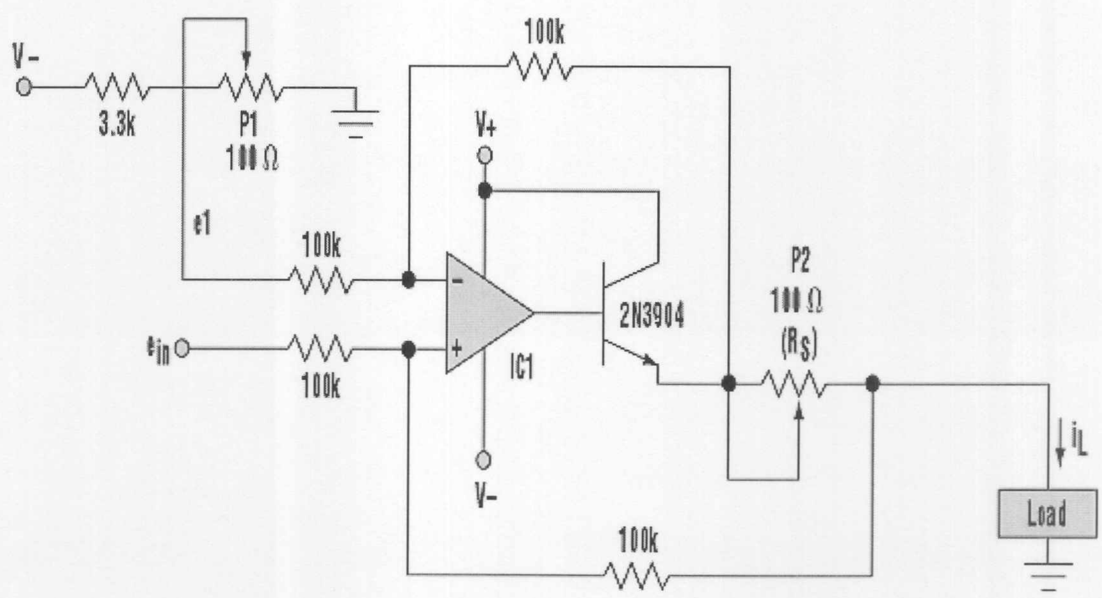
Op amp inputs at A and B are the same, so:

$e1 - e_{in} = V - I_L R_S$

$I_L = e_{in}/R_S + (V - e_1)/R_S$

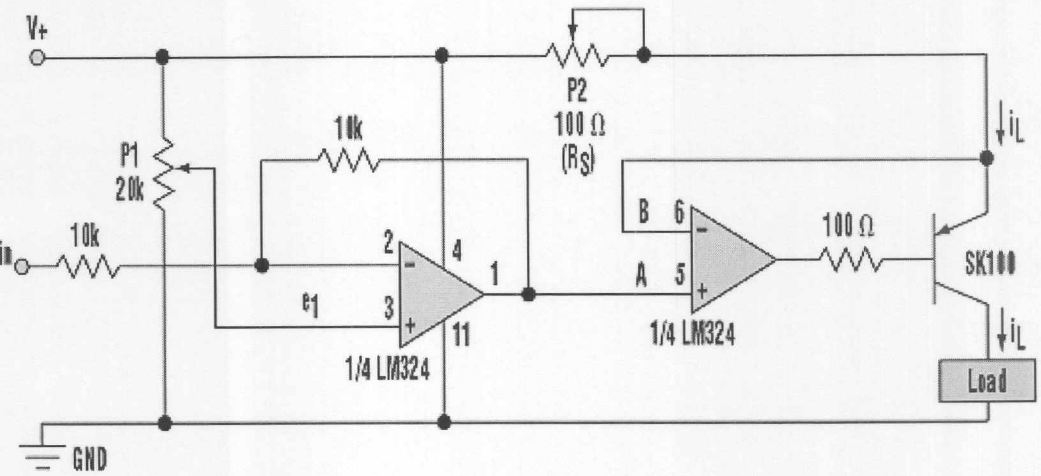
The first term is proportional to the input voltage, with the second term a constant. R_S is chosen so that the first term gives 16 mA for fu voltage, and the potentiometer is adjusted such that the second term supplies a constant 4 mA. In effect, the output is 4 to 20 mA, corre zero to full input voltage. Thus, this circuit works without using a negative power-supply rail. For the circuit shown in Figure 2, the curre 4 to 20 mA with an input of 0 to 1 V.

Figure 1



1. This conventional circuit gives 4 to 20 mA of output for an input of 0 to 1 V. First adjust P1 for zero (4 mA), then P2 for span (20 mA). The circuit needs a positive and a negative supply. Typical power supply voltages are ±15 V.

Figure 2



2. An alternate circuit provides between 4 and 20 mA of output corresponding to 0- to 1-V input. It uses only a positive supply (typical V+ = 15 V). Adjust P1 for zero (4 mA) and P2 for span (20 mA). Load resistance can reach 500 W without saturation. Replace the transistor with a Darlington pair to reduce signal inaccuracy caused by the transistor's base current.